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(54) MULTIPLY-REINFORCED STRUCTURAL PANEL

(71) We, PANEL/COMB INDUSTRIES CORPORATION, a corporation organized and existing under the laws of the State of Georgia, United States of America, of 2833 North Main Street, Gainesville, State of Florida, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to structural panels and, more particularly, to a novel honeycomb core-reinforced plastics structural panel in which additional strength is provided by numerous small columns of thermosetting plastics which extend transversely from the inside surfaces of the respective skin facing members along the corners of the cells of the honeycomb core.

Structural panels of the type currently in use in the transportation industry, specifically in the construction of van trailers, marine containers and air freight containers are usually fabricated from aluminum, steel or plywood. Aluminum structures, while relatively low both in weight and in initial cost, are susceptible to damage and punctures, and are not readily repairable in the event such damage is of major significance. Moreover, such aluminum structures provide only fair resistance to corrosion and galvanic action, are relatively expensive to maintain, and are not efficient thermal insulators. Steel structures, while lowest in initial cost are relatively heavy and not easily repairable even in the case of minor damage. Such seteel structures are also relatively expensive to maintain, provide poor resistance to corrosion and galvanic action, and are poor thermal insulators. Plywood structures are more expensive than either eluminum or steel and are relatively heavy. No such prior art structure presently in use in the transportation industry combines the features of low weight, high strength and cubic capacity, resistance both to damage and to corrosion and galvanic action, ready repairability, excellent thermal efficiency and low overall maintenance costs.

Structural panels which include honeycomb cores are known in the prior art. For example, Picket's U.S. Patent No. 3,103,460 dated September 10, 1963 discloses a light transmitting structural panel in which a honeycomb core is bonded to outer lateral surfaces of synthetic resin. In cross-section, this panel includes fillets which result when the core is embedded in the liquid resin of the outer facing members. However, this construction relies primarily upon the core itself to resist shear stresses and is susceptible to structural failure in this regard. U.S. Patent No. 2,951,004 illustrates a panel having aluminum honeycomb core and aluminum facing members which are joined together by a bonding film comprising a rubber base adhesive, an epoxy resin and a reinforcing web. This construction is directed to a metallic structure joined by a particular three-component non-metallic bonding film and likewise depends primarily upon the core itself to resist shear stresses. Finally, Gonzalez's U.S. Patent No. 3,311,253 dated October 12, 1965 discloses an acoustical panel of the honeycomb core type in which a thin matrix containing glass fibers is applied to the lateral surfaces of the core. This construction is completely unsuitable for use as a structural panel.

The structural panel of the present invention comprises a honeycomb core which incudes a plurality of elongated paper strips secured together to define a multiplicity of cells. Each cell is open at either end and has corners defined by the abutment of the elongated paper strips. The opposite longitudinal marginal edges of the paper strips define the respective opposed lateral surfaces of the core. First and second panel skin facings each include a first thermosetting resinous plastics layer which defines an outer lateral surface of the skin facing, a second thermosetting resinous plastics layer immediately subjacent the first layer which includes about 4% by weight of hollow thermoplastic spheres ranging in diameter between 10—100 microns, and a glass fiber reinforcing layer disposed within the second layer. The respective lateral surface por-

tions of the core are embedded in the respective second layers of the panel skin facings before the thermosetting resinous plastics material has cured. Finally, the present structural panel includes a mutiplicity of columns of thermosetting resinous platsics material integral with the second layer of the panel skin facing, which coumns extend along a plurality of the corners of the core cells further to reinforce and to strengthen the structural panel.

The present invention is useful both for the construction of van trailers and freight containers in the transportation industry and for load-bearing walls, roofs, floors and partions in the expanding modular housing industry. The present multiply-reinforced honeycomb core-reinforced plastics structural panel is strong, durable, moderate in cost, low in weight, resistant to damage and to corrosion and galvanic action, easily repairable and maintainable, and an effective thermal insulator. Moreover, it is estimated that a trailer or freight container constructed of the present structural panel will have a tare weight reduction of up to 1500 pounds and can provide as much as 100 cubic feet additional cargo capacity as compared to trailers or freight containers of conventional sheet and post or plywood construction. Such features make possible the achievement of substantial economic savings as the result of decreased wear and tear on equipment and increased revenue producing carrying capacity.

Brief Description of the Drawings

Figure 1 is a perspective view in partial section of the present multiply-reinforced structural panel;

Figure 2 is a sectional view taken substantially along line 2—2 of Figure 1;

Figure 3 is a sectional view taken substantially along line 3—3 of Figure 2; and

Figure 4 is a sectional view of a second embodiment of the present multiply-reinforced structural panel.

A structural panel 10 of the present invention includes a honeycomb core 11 which is made up of a plurality of elongated paper strips 12 preferably pre-treated with a phenolic resin which are secured together to define a multiplicity of cells 14. Each cell 14 is open at either end and has corners 15 defined by the abutment of the eongated paper strips 12. The honeycomb core 11 is extremely light in weight and strong under shear stress. Treatment of the paper strips 12 with phenolic resin further increases the crush strength of the core and makes it substantially impervious to water. While it is contemplated that the cross-sectional width of the core 11 range between about ½ inch and 6 inches and that the cell width range between about ⅜ inch and 1½ inch, a core having a cross-sectional width of about ¾ inch and a cell width of about ⅜ inch has been found to be generally suitable.

First and second panel skin facings 20, 21 each include an outer lateral surface layer 23, 24, respectivey, composed of a first thermosetting resinous plastics material, which usually is about 15—20 mils in thickness. A suitable resin for the outer lateral surface or gel coat layer is a thixotropic, cobalt soap-promoted, thermosetting solution of a maleic /isophthalic/propylene glycol/diethylene glycol unsaturated polyester.

The panel skin facings 20, 21 further include glass fiber reinforcing layers 26, 27 respectively which are embedded and disposed within second layers 28, 29 respectively which are composed of a second thermosetting resinous plastics. The second layers 28, 29 are immediately subjacent the first or outer layers 23, 24 of the respective panel skin facings. Each glass fiber reinforcing layer 26 or 27 may be constructed of a combination of woven cloth of glass roving bonded chemically to a chopped strand glass mat or of other suitable reinforcing material. The second thermosetting resinous plastics material of each second layer 28 or 29 is usually about 90 mils in thickness and preferably comprises a thixotropic, cobalt soap-promoted, unpigmented thermosetting solution of a maleic/isophthalic/propylene glycol unsaturated polyester resin which is inhibited against premature polymerization in the conventional manner and which is dissolved in styrene both to lower viscosity and to improve wetting properties and spraying characteristics of the resin. The second thermosetting material further comprises about 1½%—2% by weight of a methyl ethyl ketone peroxide 60% by weight solution in a dimethyl phthalate solution which serves as a catalyst.

More importantly, the second thermosetting material includes about 4% by weight of hollow thermoplastics spheres which range in diameter between 10—100 microns. Such thermoplastic spheres which are composed of vinylidene chloride and acrylonitrile polymers are manufactured by the Dow Chemical Company. They do not react chemically with the second thermosetting plastics material but physically and mechanically lower the specific gravity of the resin and permit a foaming action as they rise upwardly through the body of the second thermosetting material.

During construction of the present structural panel, the first thermosetting resinous plastics material is applied to a horizontal platen of suitable size and configuration which has been pre-treated with a conventional mold release compound. The first thermosetting material, which forms one of

the outer lateral surface layers 23 or 24, may contain pigments if necessary or desired. Thereafter, the glass fiber reinforcing layer 26 or 27 and the second thermosetting resinous plastics material which forms one of the second layers 28 or 29 are applied over the first thermosetting material. The glass fiber reinforcing layer may be pre-impregnated with the second thermosetting material, but, alternatively, the second thermosetting material may be applied directly over the first thermosetting material and the glass fiber reinforcing layer may then be placed over the second thermosetting material.

Next, the honeycomb core 11 is placed on top of the composite thermosetting plastics-glass fiber layers and embedded gently and uniformly into the second thermosetting material. Care must be taken to ensure that the lateral surface portion of the core 11 abuts the glass fiber reinforcing layer without substantially displacing the reinforcing layer in a direction toward the outer lateral panel skin facing surface. Thus, the core 11 will be firmly embedded in the second thermosetting resinous plastics material of the second layer 28 or 29 but its lateral surface portion will not penetrate into the first thermosetting resinous plastics material of the outer lateral surface area. In this manner, a firm bond between the core and the panel skin facing may be achieved without blemishing or otherwise impairing the outer lateral skin facing surface.

Once the core 11 is embedded in the second thermosetting resinous plastics material of the second layer, the hollow thermoplastic spheres cause the material to climb upwardly along a substantial number of the corners 15 of the core cells 14 to form a multiplicity of columns 30 of thermosetting resinous plastics material integral with the second layer 28 or 29 of the panel skin facing which columns 30 further reinforce and strengthen the structural panel. In many instances, the columns 30 extend across the entire cross-sectional width of the core 11.

In order to prevent pitting of the outer lateral panl skin facing surfaces which could be caused by stray thermoplatsic spheres, only one panel skin facing may be poured at a time to ensure that the hollow spheres always migrate in a direction toward the core 11. However, manufacturing time may be substantially decreased by heating the platent to about 150°F to cause the cure reaction to proceed at a rapid rate. One the cure is complete, the platen is cooled and the structure removed. The panel is completed by applying the respective thermosetting plastics and glass reinforcing layers as described above and then embedding therein the remaining exposed lateral surface portion of the core 11 in the preferred manner.

Referring to Figure 4, a structural panel of the type described above may further include a core 11*a* having cells at least partially filled with a foamed resinous plastics material 32, preferably poyurethane foam or other suitable insulating material. A structural panel of the embodiment of Figure 4 displays excellent insulation characteristics and is useful wherever insulated structures are required.

WHAT WE CLAIM IS:—

1. A structural panel comprising a honeycomb core including a plurality of elongated paper strips being secured together to define a multiplicity of cells, each cell being open at either end and having corners defined by the abutment of the elongated paper strips, the opposite longitudinal marginal edges of the paper strips defining the respective opposed lateral surfaces of the core; first and second panel skin facings, each facing including a first thermosetting resinous plastics layer defining an outer lateral surface of the skin facing, a second thermosetting resinous plastics layer immediately subjacent the first layer, the second layer including about 4% by weight of hollow thermoplastics spheres ranging in diameter between 10—100 microns, and a glass fiber reinforcing layer disposed within the second layer, the respective lateral surface portions of the core being embedded in the respective second layers of the panel skin facings before the thermosetting resinous plastics material has cured, and, a multiplicity of columns of thermosetting resinous plastics material integral with the second layer of the panel skin facing and extending along a plurality of corners of the core cells further to reinforce and to strengthen the structural panel.

2. A structural panel according to claim 1 wherein the columns extend across the entire cross-sectional width of the core.

3. A structural panel according to claim 1 wherein the core cells are at least partially filled with a foamed resinous plastics material.

4. A structural panel according to claim 3 wherein the foamed resinous plastics material is polyurethane.

5. A structural panel according to claim 1 wherein the second thermosetting resinous layer is a polyester.

6. A structural panel according to claim 1 wherein the glass fiber reinforcing layer is a woven cloth.

7. A structural panel according to claim 1 wherein each lateral surface portion of the core abuts the glass fiber reinforcing layer without substantially displacing the reinforc-

ing layer in a direction toward the outer lateral skin facing surface.

8. A structural panel substantially as hereinbefore described with reference to Figure 1 to 3 or Figure 4 of the accompanying drawings.

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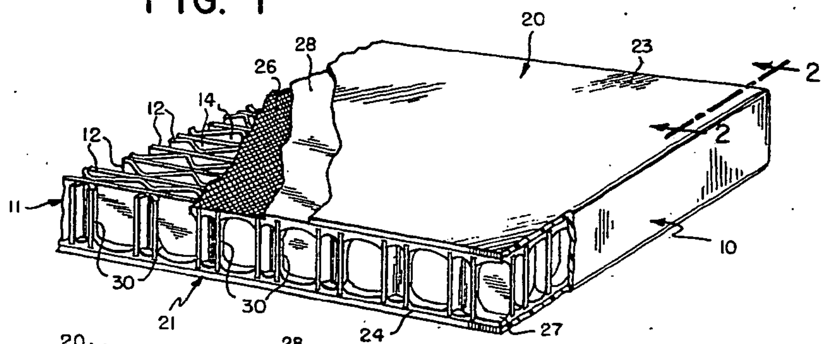
FIG. 1



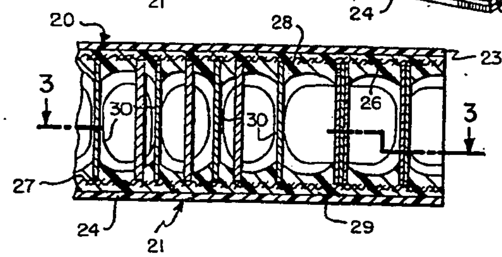


FIG. 2

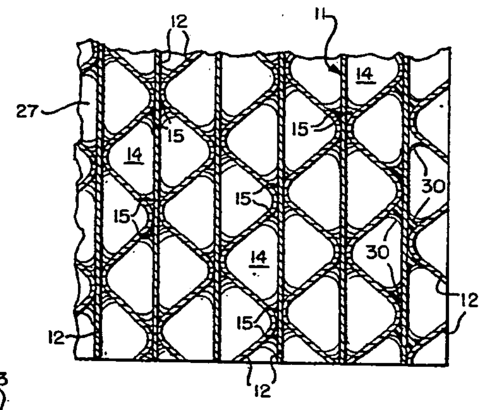


FIG. 3

FIG. 4